Germination of the polymorphic fruits of *Bidens bipinnata*

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The germination of three morphologically distinct categories of achenes of *Bidens bipinnata* was investigated. The long and medium length achenes germinated readily over a wide range of germination conditions. The short achenes showed relatively exacting germination requirements. Germination of the short achenes was enhanced by white light, red light, scarification, leaching and applied gibberellic acid and kinetin. The implications of the differences in germination behaviour are discussed.
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Die kieming van drie morfologies-verskillende tipes vrugte van *Bidens bipinnata* is ondersoek. Die lang en medium lengte vrugte het geredelik onder 'n wye reeks toestande gekiem. Die kort vrugte het egter meer spesifieke kiemingstoestande benodig. Kieming van hierdie vrugte is deur witlig, rooilig, skarifisering, uitloging, gibberellien- en kinetientoedienings bevorder. Die implikasies van hierdie kiemingsverskille word bespreek.
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Introduction

The fruits of several species of *Bidens* show polymorphism (Hilliard 1977). This feature is well known in the Asteraceae (Compositae), the capitulum structure allowing for such variation in the fruits produced (Harper 1977). Forsyth & Brown (1982) showed that the dimorphic fruits of *Bidens pilosa* exhibited different germination characteristics. The long achenes were found to germinate readily under a wide range of environmental conditions while the short achenes showed fairly exacting germination requirements.

In *Bidens bipinnata*, the fruits show polymorphism and three types of achenes can be distinguished. The short achenes (0,6

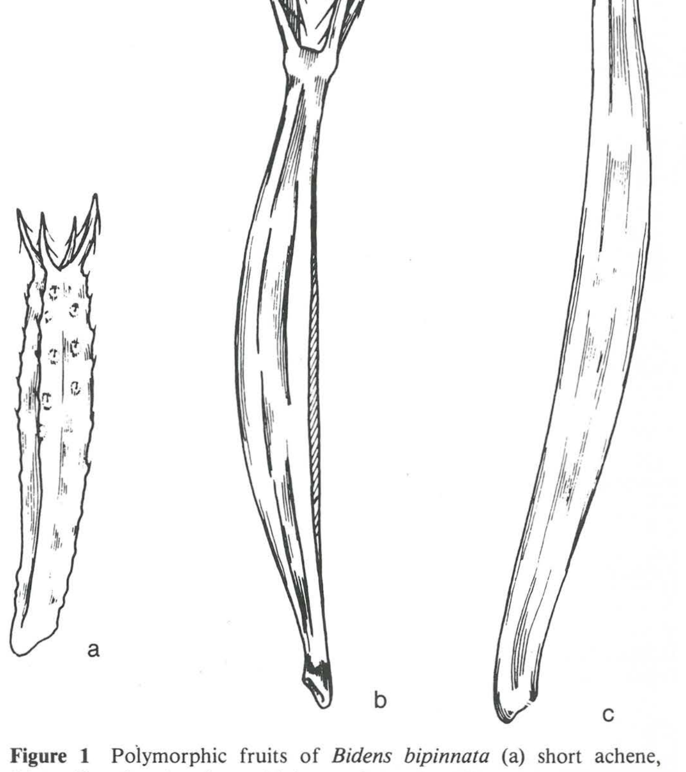

Figure 1 Polymorphic fruits of *Bidens bipinnata* (a) short achene, (b) medium length achene, (c) long achene. (× 10).

cm in length) possess reduced awns while those of medium length (0,8 – 0,9 cm) and the long achenes (1,0 – 1,5 cm) possess longer awns (Figure 1). The medium and long achenes occur centrally on the capitulum and are more numerous than the short achenes which lie towards the periphery of the capitulum.

The present study was undertaken to determine whether the three morphologically different fruit types found in *B. bipinnata* exhibited different germination and/or dormancy characteristics. For convenience the one-seeded fruits or achenes are referred to as 'seeds' in the text.

Materials and Methods

Seeds of *B. bipinnata* were collected from Newcastle, Natal and stored in brown paper bags in the dark at 20 ± 2 °C for 14 days before use. Seeds were germinated in 9 cm Petri dishes on single sheets of 7 cm diameter Whatman No. 1 filter paper, moistened with 3 cm^3 distilled water. Ten seeds were placed in each Petri dish. Unless otherwise stated, there were five replicates of each treatment (*i.e.* 50 seeds) and each trial was carried out three times. Results are given as mean percentages of these three trials.

Germination tests were conducted in the dark and in white light. Darkness was obtained by enclosing the Petri dishes in aluminium foil, and the seeds were examined for germination under a green safe light. The white light source was cool white fluorescent tubes (11 W m^{-2}). In some experiments imbibed seeds were exposed to red light (1,0 × 10^{-2} W m^{-2} nm^{-1} RL) or far-red light (4,0 × 10^{-2} W m^{-2} nm^{-1} FRL and 1,1 × 10^{-2} W m^{-2} nm^{-1} RL). The red and far-red irradiations were obtained from the description by Taylorson & Hendricks (1969).

Results and Discussion

In a preliminary test the germination of the three seed types was investigated under continuous white light and at a temperature of 25 ± 2 °C. Germination was recorded daily over 5 days. There was 90 ± 10% germination of the long seeds, 68 ± 12% germination of the medium seeds and 16 ± 10% germination of the short seeds. The difference between the figures for long and medium seeds was not statistically significant, but both long and medium seed germination was significantly greater than that of the short seeds. In a further test to determine the optimum temperature for germination, seeds were germinated in the light at 20°, 25° and 30 °C. The highest percentage germination for short seeds was at 20 °C and for long and medium seeds at 25 °C. All further tests were conducted at 25 °C.

According to Harper (1977) many weed seeds are known to be responsive to different wavelengths of light. The effect of the following treatments on germination was investigated: (i) dark control, (ii) white light, (iii) red light and (iv) far-red light. Seeds were imbibed for 24 h in total darkness at 25 °C and then subjected to 15 min of the respective light treatments. Following the light treatment seeds were returned to the dark and allowed to germinate at 25 °C.

The long and medium length seeds germinated readily regardless of the light treatment and germination was no different to that in the dark (Table 1). Germination of the short seeds, however, was markedly promoted by white and red light and to a lesser extent by far-red light. The results suggested that the short seeds had a light requirement for germination. Similar results for the small seeds of *B. pilosa* were found by Forsyth & Brown (1982). In the present study all seed was

Table 1 Germination of seeds of *Bidens bipinnata* following exposure to white, red and far-red light, respectively. Seeds were germinated in the dark at 25 °C. Figures represent means (± SE) of three trials of 50 seeds each

Light treatment	Germination %		
	Long seeds	Medium seeds	Short seeds
White	84 ± 8,7	74 ± 8,1	56 ± 12,1
Red	86 ± 13,4	76 ± 8,1	52 ± 10,2
Far-red	76 ± 6,0	78 ± 3,7	40 ± 8,3
Dark control	68 ± 4,0	74 ± 8,1	26 ± 8,7

stored for 14 days post harvest and prior to germination. It is possible that this storage in the dark induced a light requirement in a manner similar to the effect of burial on weed seeds reported by Wesson & Wareing (1969a, b) and shading by the leaf canopy on seeds of *Bidens pilosa* reported by Fenner (1980).

Exogenously applied cytokinins and gibberellins have been shown to effectively substitute for a light requirement (Kahn 1960; Ikuma & Thimann 1963; Leff 1964). A test was conducted using short seeds which were germinated in the dark with the addition of 3 cm^3 of one of the following solutions to each group of seeds: (i) distilled water control, (ii) 0,1 mg dm^{-3} gibberellic acid, (iii) 1,0 mg dm^{-3} gibberellic acid, (iv) 10,0 mg dm^{-3} gibberellic acid, (v) 0,1 mg dm^{-3} kinetin, (vi) 1,0 mg dm^{-3} kinetin and (vii) 10,0 mg dm^{-3} kinetin. In comparison with the distilled water control, both gibberellic acid and kinetin improved the germination of short seeds in the dark (Table 2). Gibberellic aid is apparently more effective in substituting for the light requirement, giving a germination of 66 ± 15% in comparison with 50 ± 3,2% for kinetin. In *B. pilosa,* gibberellic acid was also found to be more effective than kinetin in substituting for the red light requirement of small seeds (Forsyth & Brown 1982).

In some seeds scarification or mere puncturing of the seed coat will by-pass the light requirement (Thimann 1977). Scarification is also effective in cases where the seed coat impedes the uptake of water or gases (Villiers 1972). Seeds of all size classes were scarified by cutting a small notch out of the coat on the side of each seed and the seeds were then imbibed in the dark. When compared with unscarified seeds, scarification gave an enhanced rate of germination in long, medium and short seeds (Figure 2). The final germination percentage for scarified long and medium seeds was significantly

Table 2 Germination of short seeds of *B. bipinnata* after treatment in gibberellic acid solutions (0,1; 1,0; 10,0 mg dm^{-3}, respectively) and kinetin solutions (0,1; 1,0; 10,0 mg dm^{-3}, respectively). Seeds were germinated in the dark at 25 °C. Figures represent means (± SE) of three trials of 50 seeds each

	Hormone treatment	Germination %
Gibberellic acid	0,1 mg dm^{-3}	42 ± 6,6
	1,0 mg dm^{-3}	52 ± 13,6
	10,0 mg dm^{-3}	66 ± 15,0
Kinetin	0,1 mg dm^{-3}	24 ± 2,4
	1,0 mg dm^{-3}	32 ± 8,0
	10,0 mg dm^{-3}	50 ± 3,2
Distilled water control		27 ± 7,7

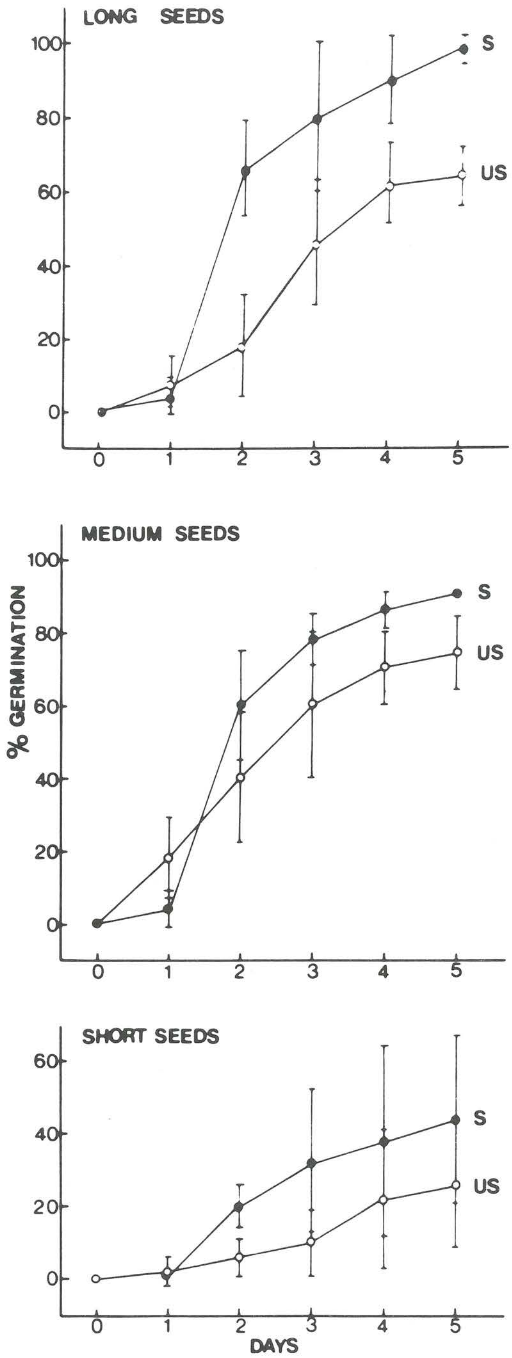

Figure 2 Germination of long seeds, medium length seeds and short seeds of *Bidens bipinnata* following scarification. Seeds germinated in the dark at 25 °C. Figures represent means of three trials of 50 seeds each. Vertical bars represent S.E. of the means. S = scarified; US = unscarified control.

greater than for unscarified seeds. For short seeds, the final germination percentage was not significantly different, suggesting that scarification does not substitute for the light requirement. In the natural system seed coats would be ruptured or otherwise scarified by abrasion in the soil or by the action of soil borne micro-organisms. Since scarification improves germination in *B. bipinnata* the natural scarification of short seeds occurring in the soil would provide a means of ensuring a 'last ditch' attempt at germination before seed embryos become non-viable with age.

When seeds were placed on moist filter paper, a brown coloured exudate was noticeable immediately around each seed. It was thought that this could indicate the presence of a germination inhibitor and, if so, leaching should improve germination.

Fifty seeds were placed in each 250 cm^3 conical flask. Distilled water (50 cm^3) was added to each flask and the flask plus seeds was agitated for 24 h in the light at 25 °C. The distilled water was replaced every 4 h to prevent the system from becoming anaerobic. Seeds were then removed from the water and placed on moist filter paper in Petri dishes in the light at 25 °C. A second group of 'unleached' seeds was germinated on moist filter paper in the light at 25 °C, to serve as a control. Figure 3 shows that for long seeds leaching accelerated the rate of germination but the final germination was the same as in unleached seeds. Leaching had no apparent effect on the germination of medium seeds. In small seeds leaching had the marked effect of accelerating the rate of germination and significantly increasing the final germination percentage. This suggested that the small seeds might contain germination inhibitors which are removed on leaching. This provides an obvious strategy for seed germination, allowing seedling development only under favourable soil moisture conditions.

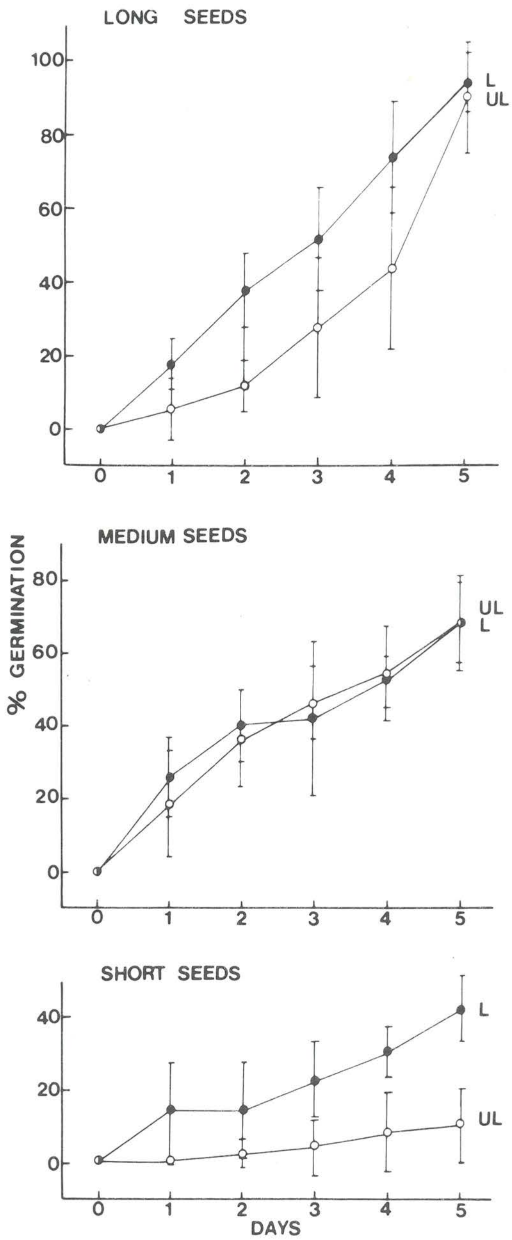

Figure 3 Germination of long seeds, medium length seeds and short seeds of *Bidens bipinnata* following leaching. Seeds germinated in the light at 25 °C. Figures represent means of three trials of 50 seeds each. Vertical bars represent S.E. of the means. L = leached; UL = unleached control.

The morphological differences between the long and short seeds are thus correlated with differences in their germination behaviour. The medium length seeds gave results which were either very similar to or the same as the long seeds or intermediate between the long and short seeds. From the point of view of germination behaviour they could most probably be included with the long seeds as a single group. The fact that the long and medium length seeds are both derived from disc florets towards the centre of the capitulum also suggests that they could be considered as a single group. Seeds intermediate in size between long and short seeds were also found in *B. pilosa* by Forsyth and Brown (1982) but no germination tests were carried out on these seeds.

In keeping with the opportunistic characteristics of weed seeds, the long and medium seeds showed no stringent germination requirements and thus many seedlings may fail to survive if unfavourable conditions prevail in the area to which the seeds are dispersed. The short seeds have more exacting germination requirements which effectively delay germination and may represent a residual population germinating only under conditions more favourable for subsequent growth of the seedlings. If they become buried in the soil their germination would be prevented by a requirement for light. The leaching of inhibitors and the breakdown of the seed coat as a result of the action of soil micro-organisms may eventually allow the light requirement to be by-passed before the seed embryos become non-viable with age.

Acknowledgements

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